Wildland Fire Behavior and Risk Forecasting

Project Team: Sher Schranz (PI), Jan Mandel, Adam Kochanski, Martin Vejmelka, Mary Ann Jenkins, Lixin Lu

Partners: Forest Service, National Weather Service

Project Summary:

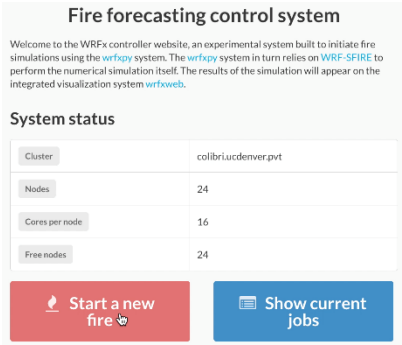
- Very high resolution weather forecast (100s of meters)
- Fuel moisture analysis, assimilation and forecast
- Fire spread, fire intensity, smoke forecast
- Web portal, FXCAVE distribution in the field

Earth Observations applied: Assimilation of data from automated sources

- Surface, upper air, radar and satellite weather through GFS & HRRR
- MODIS/VIIRS Active Fires detection
- Dead fuel moisture data from RAWS
- Satellite-based NDWI as a proxy the live fuel moisture

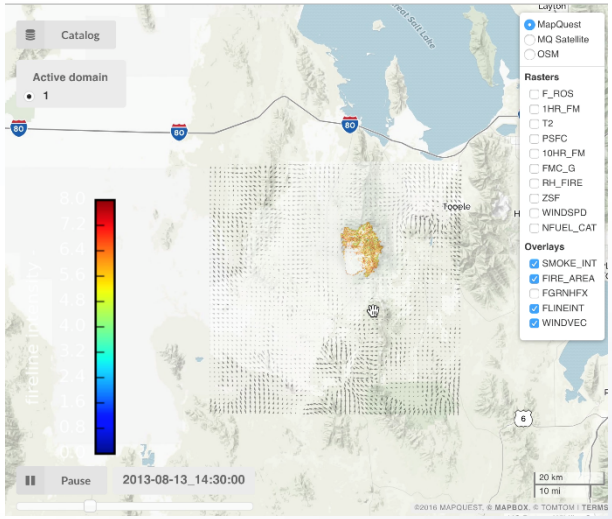
The Interactive Online System

WRFXCTRL: Submit jobs

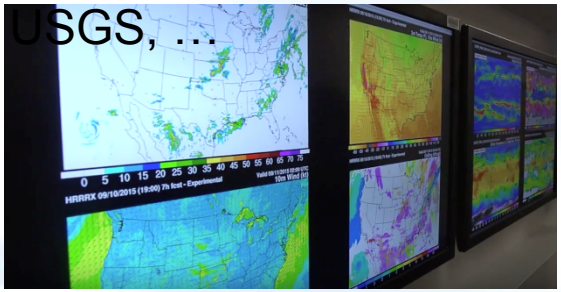


WRFXPY: Retrieve data,run jobs, process output

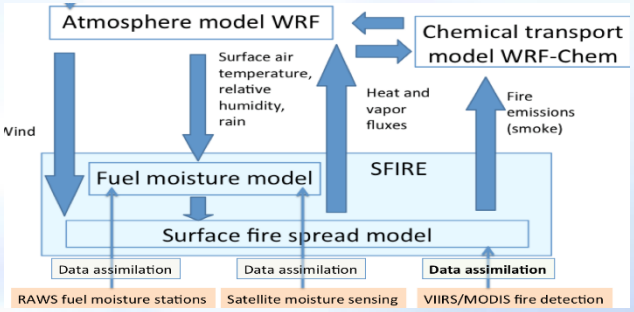
WRFXWEB: Delivery to users



Online Data: NOAA, USGS, …



Model: WRF-SFIRE

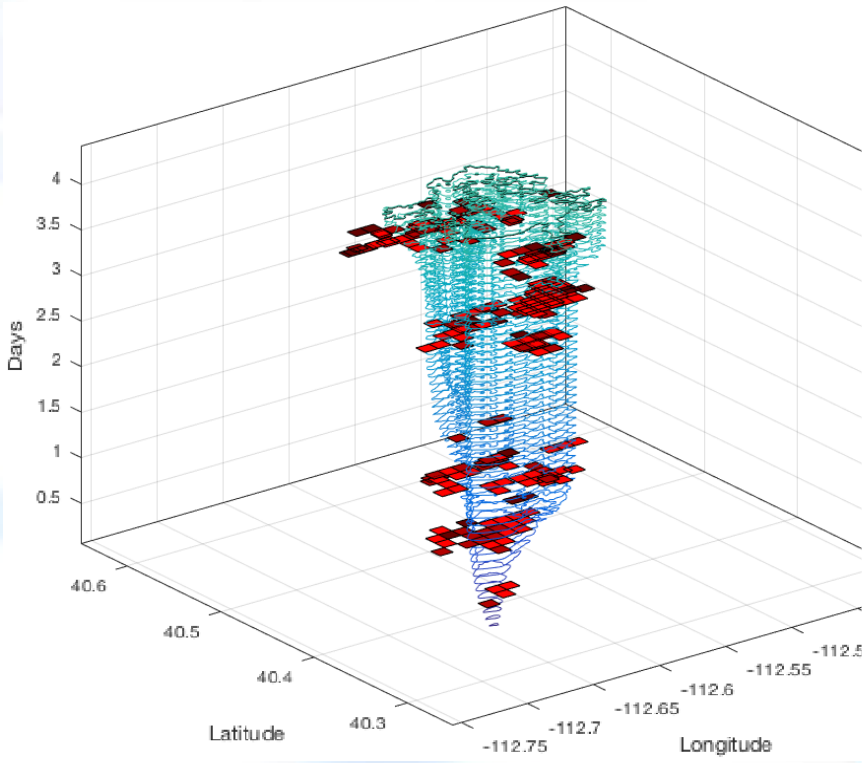


Assimilation of Active Fires Detection from satellites into the fire-atmosphere coupled model

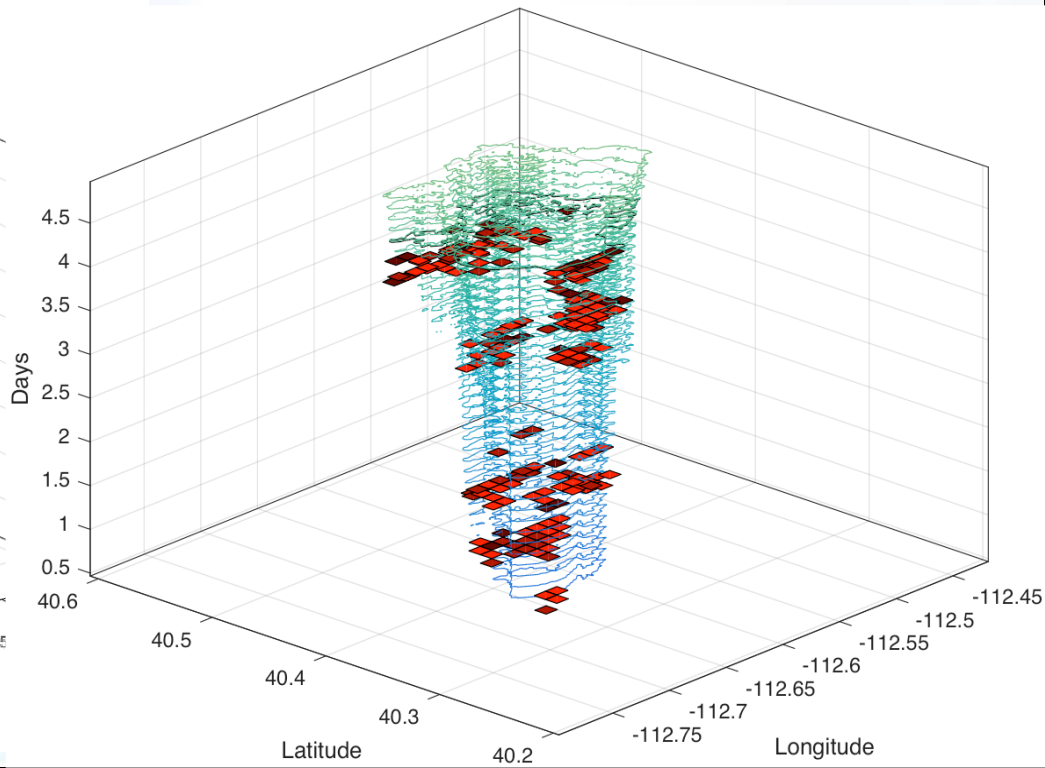
Fire model state encoded as fire arrival time at every location.

Maximize data likelihood while keeping the update small.

Forecast (before assimilation)



Analysis (after assimilation)



AppSci Domain
Phase II A.35 Wildland Fires
13-A35Phase2-0011
March 1, 2016

Wildland Fire Behavior and Risk Forecasting
NNX13AH59G

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Purpose & Objective

Automate WRF-SFIRE with initialization from NASA Earth observations for operational use by NOAA and delivery of model output via FX-Net to operational wildfire response entities such as the National Interagency Fire Center (NIFC). Specific satellite data to be used include MODIS and VIIRS active fires, Normalized Distributed Water Index (NDWI) as a proxy for live fuel moisture, and NDVI used to modify fuel loading in previously burned areas.

The benefit of this system is potentially large for active wildfire responders who need accurate depictions of fire growth and credible predictions of future fire spread.

Societal Benefit Area(s): USGEO: Disasters
Geographic Focus: CONUS
Targeted End-Users: Real-Time Fire fighting decision makers, local and national fire weather forecasters

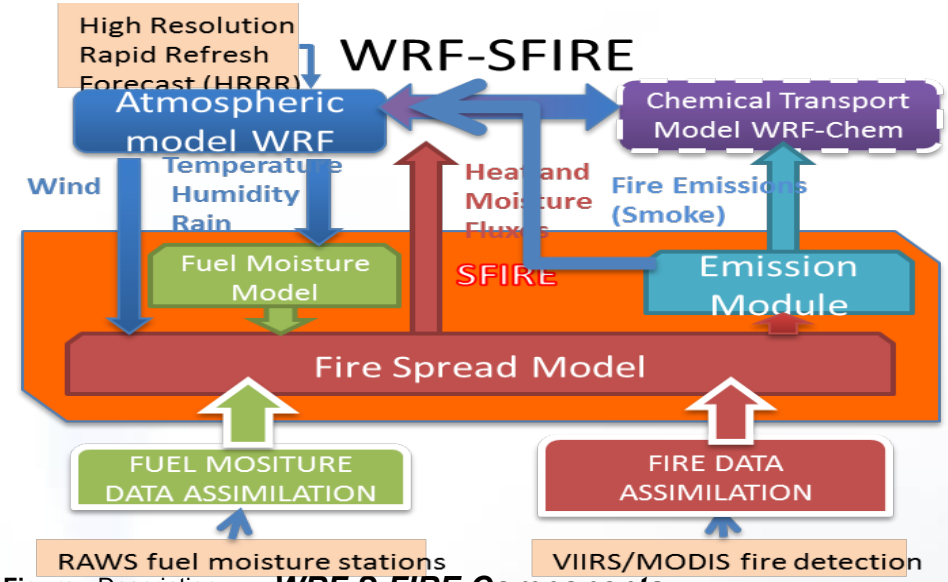


Figure: Description. ***WRF S-FIRE Components***

Approach

Technical Approach: *1) Phase III web interface and model data delivery via web, FX-Net and NOAA Earth Information System (NEIS) system : Risk – NOAA Research policy changes and NOAA/NWS operational security policy halting data delivery via NOAA operational hardware (AWIPS II Thin Client) . 2) Phase III model running in real time: Risk – identifying operational hardware and data feeds at NOAA or USFS agencies to execute model runs. (Possible USFS process identified.)*

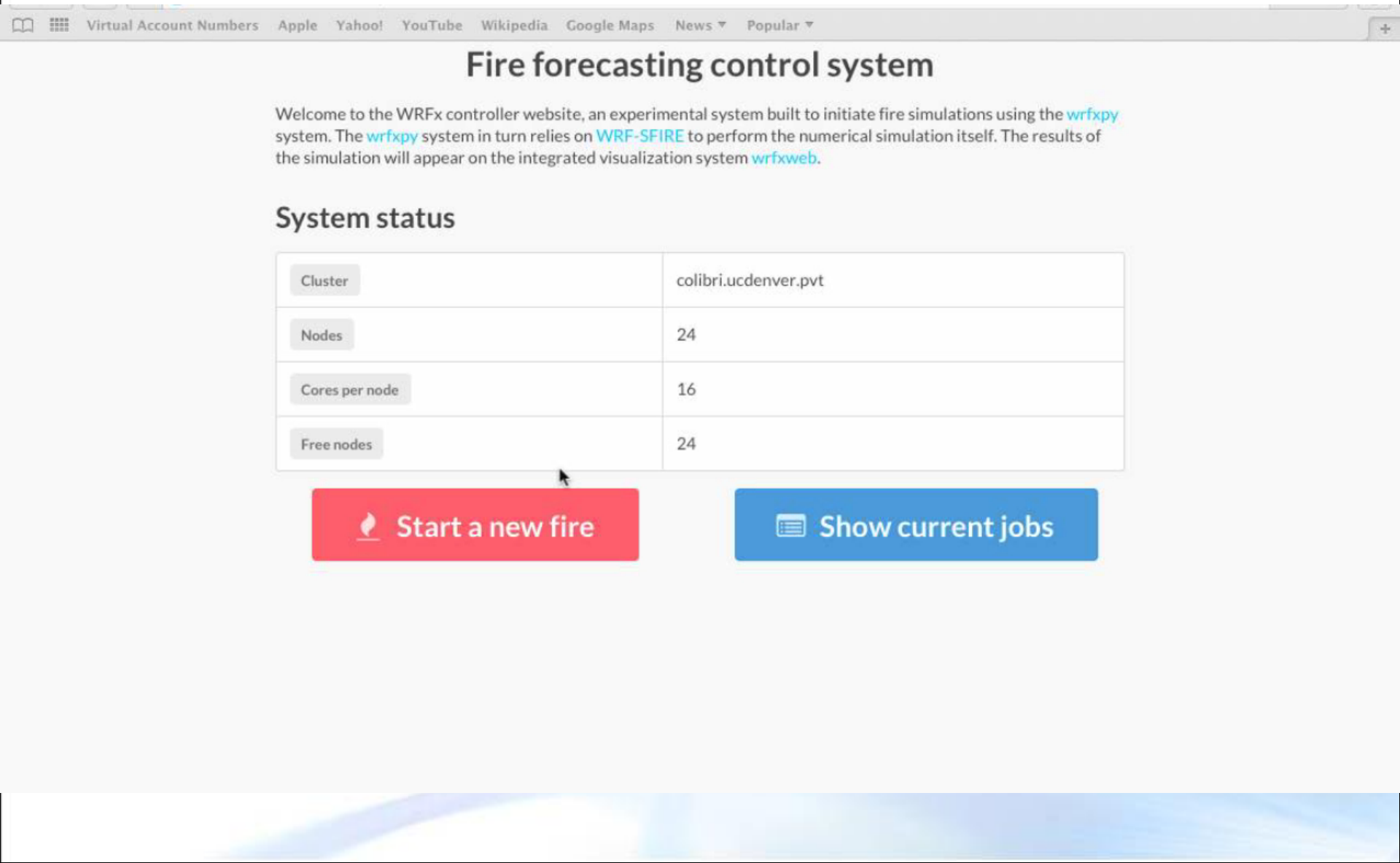
Scientific Approach: *1) Phase III satellite assimilation and modeling system tuned : Risks – satellite sources for real-time operation. Risk – NOAA and *USFS operations and researchers needed to do this. 2) Fire danger model validation: Risks – required additional fire cases with adequate observations to validate model. Data from the USFS is available.*
** Collaborative agreement in process between USFS and CSU*

Key Milestones

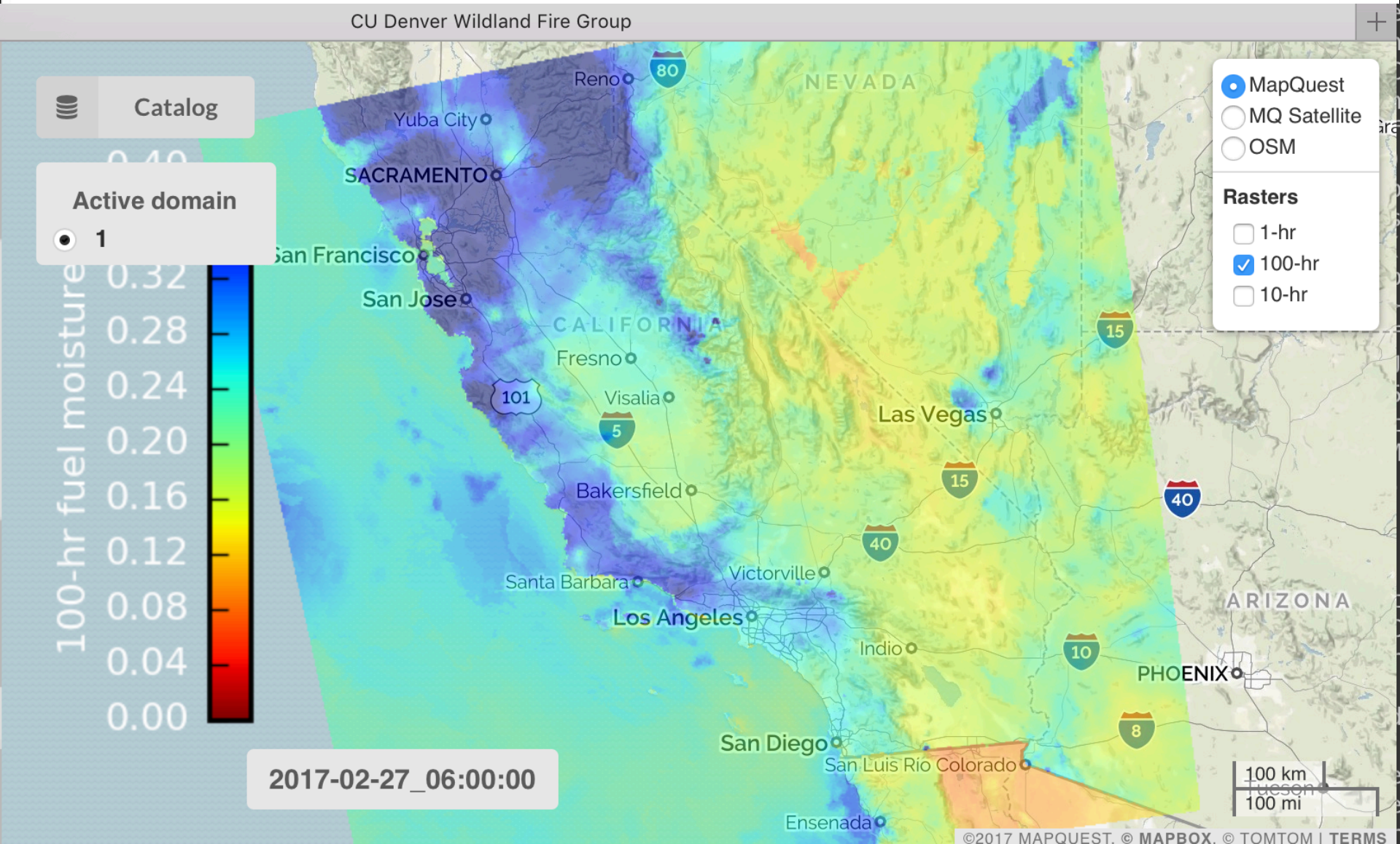
Milestone Statement	Date
Calculate and assimilate NDWI calculations into Model	**6/15**
Acquire fire locations from Satellite fire detection system	**8/15**
Web Portal completed	**2/16**
SIRE running in real-time (provide a forecast)	**4/16**
Real-Time SFIRE output available on FX-Net (Ops Security Issues)	7/16
Model Evaluation and Testing (USFS Plans)	6/17

ARL_{Start} = 1 **ARL =4** **ARL_{Goal} = 5**

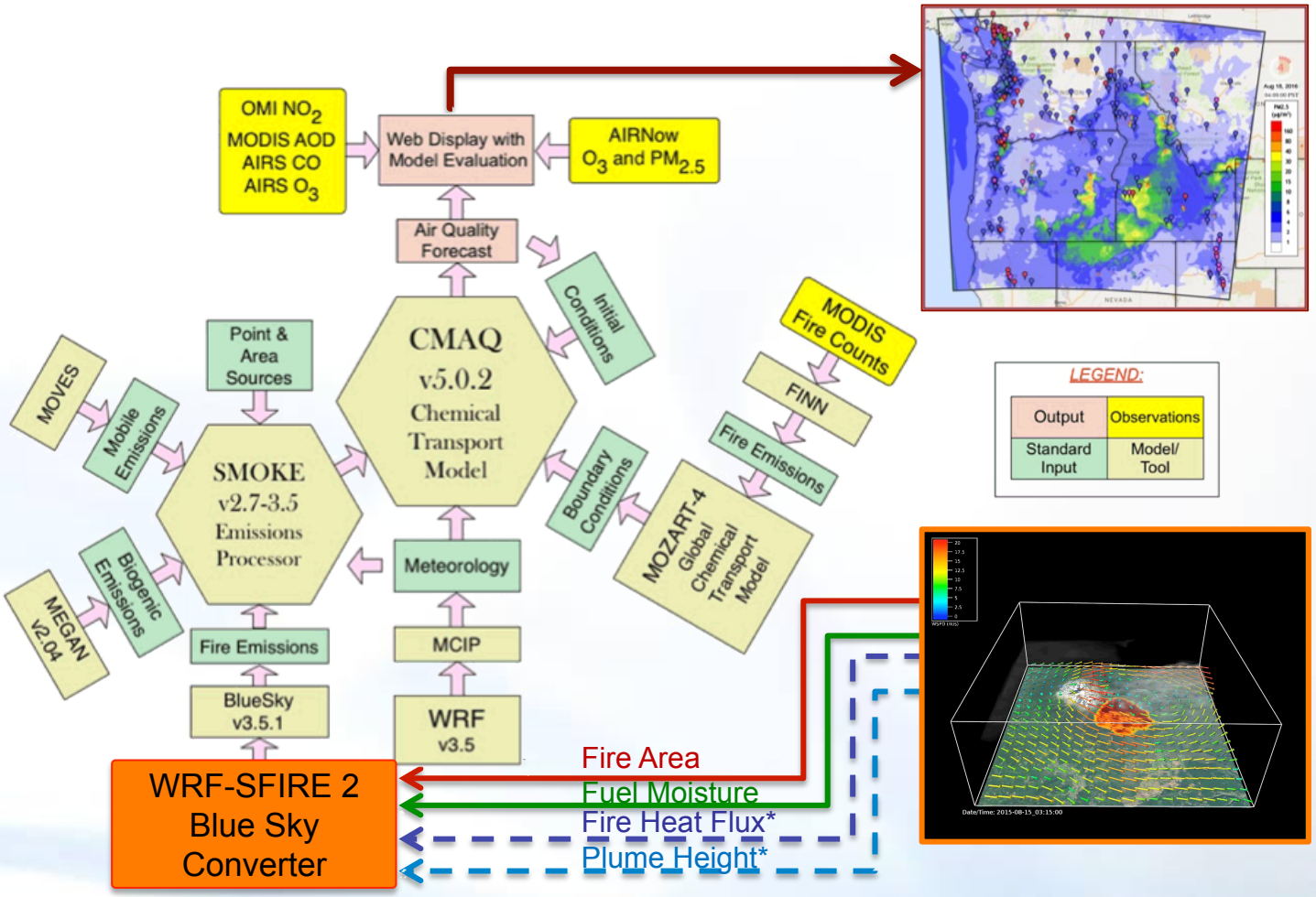
Model Execution Online Interface



Nowcasting dead fuel moisture with RAWS moisture data assimilated



Integration of WRF-SFIRE with the AIRPACT-5 air quality system



PI Overall Assessment

Summary of Challenges; Problems; Objective Analysis

Challenge: Model Data Delivery via FX-Net not funded due to policy changes at NOAA resulting in funding being redirected from Fire Weather research. Current funding profile is zeroed out. The FX-Net system has been transitioned to FXCAVE – currently being used by the National Interagency Fire Center Fire Weather Forecasters at national GACC's.
Analysis: Additional funding is being requested by NOAA developers to add SIRE output to the FXCAVE system.
Challenge: An operational version of the model will not be run by NOAA.
Analysis and Planning: Joint Venture Agreement with the USFS will allow the model to be run in a quasi-operational mode. The model will be evaluated for use in USFS operations.

Summary of Positive Progress

FX-Net data delivery: There are no technical challenges or roadblocks. Funding is the current roadblock.

Operational Model Runs: The SFIRE system is now a modular, fully packaged system. It can be installed on LINUX servers with the packaged instructions and model runs initiated and visualized via the web interface. SFIRE can be executed and output visualized through the online portal.

Overall Assessment

SFIRE has emerged as a research community coupled model with strong operational forecaster interest.

PI Assessment of Future Project Progress

NOAA Earth Information System (NEIS) and FX-Net Data Delivery: Data can be visualized by this system. Case studies need to be identified for visualization.

Operational Model Runs: Joint Venture Agreement holds great promise to allow model to run at USFS facility for evaluation and testing by research and operations fire weather professionals.

Modeling systems such as WRF SFIRE need computing resources for testing and to keep this system available to the larger research and operations community. NASA has multiple clusters and it would be extremely helpful to have a fraction of those computing resources shared with us.

2017 Funding: Will follow proposed spending plan.

2017 Shortfall: $20k for SFIRE output ingest by FXCAVE

$ARL_{Start} = 2$ $ARL_{Most\ Recent} = 4$ $ARL_{Goal} = 5$

PI Assessment: Transition Plan (1 of 4)

Model Evaluation

NASA Socio-economic Impacts Project

During the next year of the socio-economic impact study's model validation and development we are comparing the fire progression in the model and, in reality, in greater detail than before on the level of individual properties. Firefighting actions will also be implemented in the model on a large scale by modifying the fuel and moisture fields. Model improvements are incorporated into the SFIRE system in the process.

Joint Venture Agreement: Rocky Mountain Center-Colorado State University/ CIRA

Project Title: "*Development of regression models for predicting large-fire ignition probabilities for Predictive Services Areas (PSA). Testing the forecasting capabilities of the coupled WRF-SFIRE model*."

PI Assessment: Transition Plan (2 of 4)

WRF-SFIRE Community

SFIRE code available for download and evaluation. Downloaded by:

- Fire-Modified Meteorology in a Coupled Fire–Atmosphere Model, *Journal of Applied Meteorology and Climatology, AMS, March, 2015*
- Large eddy simulation of atypical wildland fire spread on leeward slopes
Colin C. Simpson, Jason J. Sharples, Jason P. Evans, and Matthew F. McCabe,, International Journal of Wildland Fire **22**, 599-614, 2013 doi:10.1071/WF12072
- US Naval Research Laboratory (Scott Rabenhorst)
- University of Calgary (Atoossa Bakhshaii)
- The Role of Heat Extinction Depth Concept to Fire Behavior: An Application to WRF-SFIRE Model
Kartsios, S and Karacostas, Theodore S and Pytharoulis, I and Dimitrakopoulos, AP
Perspectives on Atmospheric Sciences} 37—142 Spring 2017
- Jonathan Guerrette CU Boulder

SFIRE Online Interface

Interactive, online model execution and visualization interface available by request and managed based on computing resources. Current users include GACC forecasters.

Operational Data Distribution

- FXCAVE system integration awaiting funding.
- Visualized by NEIS system. System is available for licensing from NOAA.

PI Assessment: Transition Plan (3 of 4)

Budget:

- Approximately an additional $20k required to integrate SFIRE output data into FXCAVE (not in current budget).
- Phase III budget on track, no NCE required
- Budget extended for Socio-economic study to 2018, will need to request NCE

Potential to add temporary personnel via USFS Joint Venture Agreement to transition current code into operational-grade code.

PI Overall Assessment: Transition (4 of 4)

Goal: SFIRE software transition to USFS system
Outlook: May not be completed prior to the current project end date.

Goal: Ingest SFIRE output into NIFC operational system (FXCAVE)
Outlook: In need of additional funds to complete.

Ideal Endstate: A baselined version of the SFIRE model, initialized with the NWS operational HRRR/Chem model with enough computing resources to allow up to 3 operational model runs simultaneously. Additional resources available for research simulations and model improvement testbed.

Modeling systems such as WRF SFIRE need computing resources for testing and to keep this system available to the larger research and operations community. NASA has multiple clusters and it would be extremely helpful to have a fraction of those computing resources shared with us.

Ideally cloud resources would be available to expand model runs for simulations, field studies and testbed activities.

Budget progress and future plans to spend down the funding by year.

ARL_{Start} = xx $ARL_{Most\ Recent}$ = xx ARL_{Goal} = xx

PI Overall Assessment: Impact

Honest Opinion

SFIRE has the potential to be a powerful addition to the wildland fire decision-support toolbox.

Project's Impact/Potential as an Analogy

The coach always needs another play in the playbook – SIFRE could be a game changer!

Relevant Publications, Awards, Accomplishments

Notable achievements

1. We are now using our online fire simulation system for our regular work. The system allows to start fire and smoke simulation by pointing on a map anywhere in the CONUS and it downloads all necessary data automatically. The system also provides fuel moisture nowcasting for CONUS from weather data feeds and with RAWS fuel moisture data assimilated. The visualization of the outputs is accessible at http://demo.openwfm.org.
2. The WRF-Sfire model was adopted for use in the classroom at the Font du Lac Tribal and Community College in Wisconsin, and it is scheduled to be used in Spring 2017.

Journal papers

1. M. Vejmelka, A. K. Kochanski, and J. Mandel, Data assimilation of dead fuel moisture observations from remote automated weather stations, *International Journal of Wildland Fire* 25, 558-568, **2016**
2. A. K. Kochanski, M. A. Jenkins, K. Yedinak, J. Mandel, J. D. Beezley, and B. Lamb, Toward an integrated system for fire, smoke, and air quality simulations*. International Journal of Wildland Fire* 25, 534-546, **2016**

Conference papers (extended abstracts)

1. Mandel, J., A. Fournier, M. A. Jenkins, A. K. Kochanski, S. Schranz, and M. Vejmelka, Assimilation of satellite active fires detection into a coupled weather-fire model, *Proceedings for the 5th International Fire Behavior and Fuels Conference April 11-15, 2016, Portland, Oregon, USA*, International Association of Wildland Fire, Missoula, Montana, USA, 17–22, **2016**
2. Ignition from fire perimeter and assimilation into a coupled fire-atmosphere model, Adam K. Kochanski, Mary Ann Jenkins, Volodymyr Kondratenko, Jan Mandel, Sher Schranz, Martin Vejmelka, Craig Clements, Braniff Davis. *Proceedings for the 5th International Fire Behavior and Fuels Conference April 11-15, 2016, Portland, Oregon, USA*, International Association of Wildland Fire, Missoula, Montana, USA, 80–85, **2016**

Conference presentations

1. Using Earth Observations to Assess the Socioeconomic Impact of Human Decision Making during the Suppression of a Wildland Fire, Van V. Miller, Adam Kochanski, Jan Mandel, Vince Herr, Sher Schranz. Poster, 2016 AGU Fall Meeting, December 14, 2016
2. Weather-driven fire emission forecasting for air quality models, Adam Kochanski, Joseph Vaughan, Brian Lamb, Serena Chung, Vikram Ravi, Susan O'Neil, Farren Herron-Thorpe, Mary Ann Jenkins, Jan Mandel, Sher Schranz, 2nd International Smoke Symposium, Long Beach, CA, November 14-17